

Testing Centres: Task of the IEA 4E Electric Motor Systems Annex (EMSA)

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Abstract

The International Energy Agency (IEA) Implementing Agreement for a Co-operating Programme on Efficient Electrical End-Use Equipment (4E) was set up in 2008 and is currently supported by around 12 countries. The aim of this Implementing Agreement is to promote the wider use of more energy-efficient electrical equipment. An Electric Motor Systems Annex (EMSA) was launched at the end of 2008 as part of the IEA 4E Implementing Agreement and is made up of a number of Tasks.

Task C 'Testing Centres' began in early 2009, led by Australia with participation from Switzerland and Denmark. The aim of this work is to raise the quality of motor testing worldwide by developing an international network of testing laboratories. The 'Testing Centres' network has been developing conventions on unresolved points of detail on test method procedures. More specifically, there is a need for this work so that suppliers, purchasers and regulators can be more confident of the claimed performance of motors on the market. Two workshops have been held since this Task began. These workshops have informed the development of a guide to electric motor testing methods in IEC 60034-2-1:2007 which is the IEC test method standard for motors.

1. Background

1.1 Electric Motor Efficiency

Electric motor applications in industry are major consumers of electricity around the world. It is estimated that 300 million industrial electric motors (between 0.75kW and 375kW) are currently installed with an estimated 30 million motors sold each year¹ and are responsible for 4.3 giga tonnes of CO₂-equivalent greenhouse gas emissions.² Therefore, improvements in energy efficiency of motor systems reduces greenhouse gas emissions, as well as saving energy costs. Concerns about energy efficiency have led to an increase in international efforts to improve the efficiency of the complete motor system. However, there are many barriers to improving the energy efficiency of motor systems as a whole. Therefore regulators focus on the individual pieces of equipment within a system, such as motors.

The potential benefits from improved electric motor applications have been recognized by many governments which have implemented mandatory minimum energy performance standard (MEPS) for three-phase cage rotor induction motors. Motors from 0.75 kW up to 375 kW make up the majority of motors covered by standards around the world.

At the moment, Australia, Brazil, Canada, China, Costa Rica, Israel, Mexico, New Zealand, Switzerland, Taiwan and the United State have introduced MEPS for motors but with varying mandatory levels. Additionally, many countries are set to raise their standards in the coming years and the European Union set mandatory MEPS for motors for the first time in 2011.² The new International Electrotechnical Commission (IEC) efficiency classes standard IEC 60034-30³ describes

a new labelling system (IE1, IE2, IE3) for motors. Currently IE2 is the highest efficiency level that is mandated by a number of countries, with the United States moving to IE3 in 2011.

In addition to the differences in mandatory efficiency standards and levels, many different test methods are used around the world. Inconsistencies within test methods and the number of different international testing methods being used make it more difficult to implement energy efficiency programs and market transformation programs.



1.2 IEC Test Method Standard

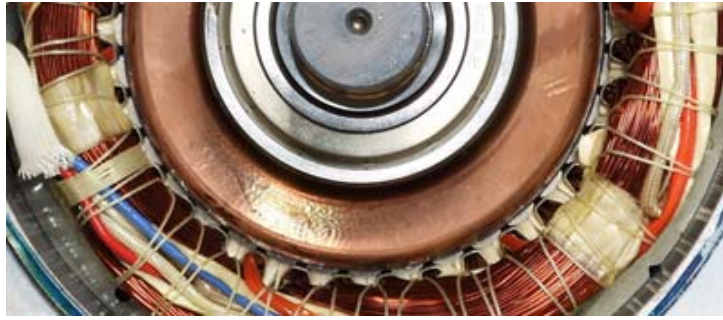
The variations in motor test method standards led to the International Electrotechnical Commission (IEC) publishing *IEC 60034-2-1:2007 'Standard methods for determining losses and efficiency from tests (excluding machines for traction vehicles)* in September 2007.

The historical need for test procedure improvements is largely due to the range of methods for determining motor efficiency. For example, the various techniques to measure stray load losses used by different test methods result in distinctly different test results. The IEC standard establishes methods for determining efficiencies of rotating electrical machines as well as the methods for obtaining specific losses. Accurate determination of stray load losses has been historically difficult because it requires accurate measurement of torque and speed. Due to technological improvements, this measurement has more recently become feasible to do.

IEC 60034-2-1 was developed to harmonise test methods to be consistent with most of the world and is presented as the “preferred” test method standard. However, this IEC test method standard is widely recognised as requiring further improvements in order to harmonise testing methods. Table 2 in IEC 60034-2-1⁴ describes ten distinct test methods which can be used to measure motor efficiency. As well as this, there are some ambiguities within the standard. These ambiguities can lead to inconsistent results between different laboratories, due to differences of interpretation. The high number of testing options and sometimes imprecise language of the IEC standards are both points that need further improvement.

1.3 IEC Round Robin

Over the past few years, the IEC has organised and run an international motor testing round robin in order to address the variation in reported energy efficiency by motor manufactures and testing laboratories. The aim of the round robin was to provide experience in regard to IEC 60034-2-1. More specifically the round robin was expected to aid in the assessment of the different test methods and supply test data to evaluate measurement deviations between laboratories. Seventeen laboratories from 11 countries submitted a total of 194 individual test reports. 75 different motors were tested in the IEC round robin. The final conclusions of the round robin report are still under discussion but are expected to help inform the current revision of IEC 60034-2-1.



2. The International Network of Motor Testing Centres

2.1 Overview of the Project

The Electric Motor Systems Annex (EMSA) was established in 2008 as part of the International Energy Agency (IEA) Implementing Agreement for a Co-operating Programme on Efficient Electrical End-Use Equipment (4E). EMSA is made up of a number of Tasks addressing various aspects of improving motor system efficiency.

The IEA 4E EMSA Task 'Testing Centres' has been seeking to further develop work on motor testing methods by building an international network of testing centres. Task C 'Testing Centres' began in early 2009, led by Australia with participation from Switzerland and Denmark. The overarching goal of the project is to establish an ongoing dialogue between laboratories to encourage a common approach to motor efficiency testing and the procedures described in the IEC 60034-2-1 test method standard.

2.2 Objective

The Testing Centres Task seeks to establish a forum in which laboratories from around the world can share best practices and develop coordinated responses to questions arising from procedure details of test method standards. Additionally, a network of testing centres will be able to better meet the increasing demands of industry and in turn encourage confidence in the declared motor performance. This is important for suppliers, purchasers and regulators.

This Task is expected to have two major components: 1) Educate and stimulate laboratories to improve quality of testing around the world and 2) Policy development in regards to check testing regimes for regulators.

There appear to be five main categories for errors in testing:

- The accuracy and interpretation of the testing procedure;
- Instrumentation uncertainty;
- Manufacturing/material deviations;
- Operator errors; and
- Laboratory variations.

Increased communication and sharing of expertise and experience between testing centres is expected to decrease the errors from these categories. Interpretation of testing procedures has the potential to be improved via best practice guidance documents and improved communication between laboratories. Sharing experiences in instrumentation uncertainty will also assist in improving the quality of testing around the world. Errors resulting from operator errors are likely to be minimised for similar reasons. The

last category, laboratory variations, is also expected to be addressed as part of discussions between the proposed network of test centres.

Governments regulating energy efficiency in motor equipment and those working to maintain quality assurance of products entering the market need to be able to rely on test laboratories. Delegates at various conferences including Motor Energy Performance Standards Australia 2009 (MEPSA) have stressed that compliance and testing methods need to be improved before introducing higher minimum efficiency performance standards (MEPS).

Quality information underpins the ability of regulators to properly assess motor efficiency when implementing new standards. Consistent testing helps ensure a level playing field for all motor suppliers. It is only possible to have an effective compliance and check testing program if there is reliable testing of efficiency and a robust test method standard. Otherwise action cannot be taken against any suppliers who may be supplying non-compliant products.

Manufacturers and purchasers of electric motor equipment also have a lot to gain from improvements in testing laboratories and their ability to properly measure motor efficiency. Consistency in test results from laboratories encourages confidence for both the manufacturer and purchaser. When making a purchasing decision for industrial equipment small differences in efficiency can make a significant change in end energy use due to the overall volume of operation, and therefore operating cost. It is to the benefit of both the manufacturer and purchaser to be able to more accurately calculate energy use for specific products.

2.3 Scope of Work

The scope of work for Task C – Testing Centres includes the following:

- Build an international network of test laboratories;
- Hold annual workshops for test laboratories;
- Build a web forum for online discussion between test laboratories;
- Produce guides to testing and the IEC test method standard to help improve the quality and consistency of motor testing; and
- Encourage improvements in compliance and check testing around the world.

Some of the work of this Task will be progressed by small working groups of laboratory experts.

2.4 Workshops and the Testing Centres Network

Two successful workshops have been held since the Testing Centres Task began in early 2009. The first workshop was held in Nantes, France immediately after the EEMODS09 conference on 17 September 2009. Testing Centres members attended from Europe, Asia-Pacific and North and South America and discussed motor testing best practice, as well as interpretation issues with IEC 60034-2-1.

The second Task C Testing Centres workshop was held on 26 October 2010 in Zurich, Switzerland. Nearly 40 representatives from test laboratories around the world attended this workshop. The delegates found the event very useful and feedback shows that there is plenty of enthusiasm for continuing. The delegates really valued both the practical information on testing motors and being closer to what IEC is doing. They also provided detailed and useful input to the *Guide for the Use of Electric Motor Testing Methods Based on IEC 60034-2-1:2007*.

By May 2011, there were nearly 60 members of the Testing Centres Network from 28 different countries, including members from several African countries. The types of motor testing centres run by members include independent laboratories, university/academic laboratories and manufacturer/supplier laboratories. The network is still growing, and experiences a leap in numbers with each annual workshop.

2.5 Testing Centres Web Forum

In 2009, a web forum for the Testing Centres network was set up on the Leonardo Energy website. It has had mixed results. 15,000 visitors visited the Testing Centres Web Forum in its first year but there have been minimal comments on the articles which were designed to provide a forum for comments and discussion. There is a slow but steady stream of registrants for the network via the Testing Centres web forum.

The web forum can be accessed at:

www.leonardo-energy.org/testing-centres-motor-efficiency

2.6 Guidance Documents

One of the main outputs of Task C – Testing Centres to date has been the production of the *Guide for the Use of Electric Motor Testing Methods Based on IEC 60034-2-1:2007*. The history of this document goes back several years. The MEPSA 2009 conference⁵ (Motor Energy Performance Standards Australia 2009 – regulating motors and motor systems components) brought together motor experts from around the world to review global progress on motor and motor system efficiency. MEPSA 2009 was held at the University of Sydney, Australia from 4-5 February 2009.

During MEPSA discussions on the IEC 60034-2-1 test method standard, it emerged that there are some important points of detail which appear to be ambiguous or potentially confusing. For example, it is not clearly stated whether oil seals should be left in place during testing, nor the sequence of some of the tests. It was recognised that it is important to have a common approach on points such as these. Test method standards that are clear and unambiguous ensure a 'level-playing field' for manufacturers and suppliers.

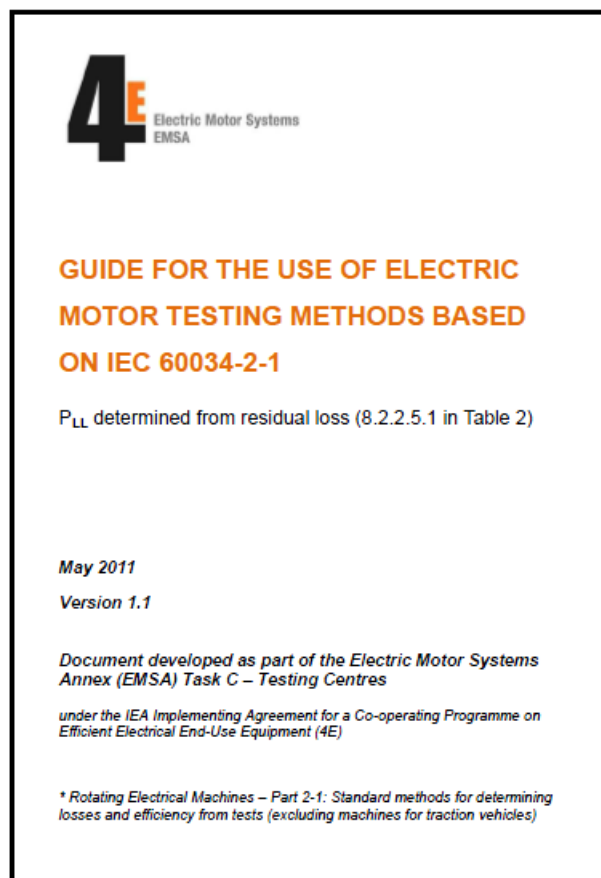


Figure 1 - Guide for the Use of Electric Motor Testing Methods Based on IEC 60034-2-1:2007

This work was progressed by Task C – Testing Centres. Input from test laboratories and other experts around the world has helped inform the development of this document. The topics covered by the Guide are:

- Flow charts for PLL determined from residual loss
- Removal of sealing elements
- Selection of measurement points for load and no-load tests
- Measurement techniques and data averaging
- Temperature measurement
- Calculation algorithm

Each section describes the background and the issues behind each topic or clause and follow with the interpretation of the clause as widely agreed at the Testing Centres workshops. Several of the topics (measurement techniques and data averaging, temperature measurement and calculation algorithm) do not yet have a widely-agreed interpretation so only a description of the issue and general guidance has been provided at this stage. Future work on this document may be able to provide firmer guidance on these, and other topics, at a later stage.

The *Guide for the Use of Electric Motor Testing Methods Based on IEC 60034-2-1:2007* was circulated to Testing Centres members in May 2011. The Guide is also expected to help inform the current revision of IEC 60034-2-1:2007 by the IEC Technical Committee 2 Working Group 28.

2.7 Software Round Robin

Another important and informative part of the Testing Centres workplan has been a software round robin. One of the members, CalTest in Australia, developed a set of sample test data for an 11kW 2 pole motor. This test data was circulated to ten members at the second Testing Centres workshop in 2010. The aim of this project was to compare the consistency of efficiency calculations and calculation algorithms by using the exactly same test data.

This software round robin has demonstrated variability in the results produced by different laboratory calculation algorithms. The results of this software round robin will be presented at EEMODS11 by Andrew Baghurst. The results of this round robin is expected to eventually inform a future Testing Centres guidance document on calculation algorithms and may also help to inform the revision of IEC 60034-2-1. (See the EEMODS11 paper “Developing a standard algorithm for the calculation of induction motor efficiency based on International Standard IEC 60034-2-1” by Andrew Baghurst, John Yelland, Pierre Angers and Martin Doppelbauer)

2.8 Future Work

The work of the Testing Centres network will continue as members have found the workshops and information exchange valuable to date. Another workshop will be held next to the EEMODS11 conference in Alexandria, VA in the US in September 2011.

Further guidance documents will be developed, including best practice guides for motor test laboratories and guidance on calculation algorithms. Task C – Testing Centres will also explore how best to promote improvements in compliance and check testing around the world.

3. Conclusion

There is international consensus that in order to improve upon MEPS and advance the world of motor efficiency, improvements in motor testing methods are needed, specifically in regards to inconsistencies between methods, language ambiguity and the large number of different tests being used. The global movement toward a harmonised motor efficiency test method began in 2007 with the introduction of IEC 60034-2-1.

To help address the needs of motor test laboratories to improve the quality and consistency of efficiency testing around the global, a Testing Centres network was established in 2009. By May 2011, there were nearly 60 members from all around the world, including members from Europe, Asia-Pacific, Africa and North and South America.

Two successful workshops have been held so far, with a third planned to occur around EEMODS11 in the US. The popularity of these workshops and the enthusiasm from participants has demonstrated the value of this network. A web forum has been developed to allow online discussion of testing issues, but this part of the project has had mixed success.

The most significant output of Task C so far has been the production of *Guide for the Use of Electric Motor Testing Methods Based on IEC 60034-2-1:2007* which helps provide guidance to motor test laboratories. This guide was circulated to Testing Centres members in May 2011. Further guidance documents will be produced at a later stage to address laboratory best practice, or other ambiguities with the IEC test method standard.

The ultimate aim of the project is to foster an ongoing dialogue between international testing centres. In the longer term, this will enable testing centres to share information that in turn will lead to a common approach to testing electric motor efficiency. Improvements in international testing methods and an international forum for testing centres will give more confidence to regulators, manufacturers and motor purchasers.

Acknowledgements

A/Prof Andrew Baghurst (CalTest) has provided an invaluable contribution in producing the *Guide for the use of electric motor testing methods based on IEC 60034-2-1:2007* and organising the software round robin. Testing Centres members from around the world and EMSA members have also made a significant contribution to this work, particularly at the Testing Centres workshops. We also would like to acknowledge Leonardo Energy's assistance with setting up the web forum.

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